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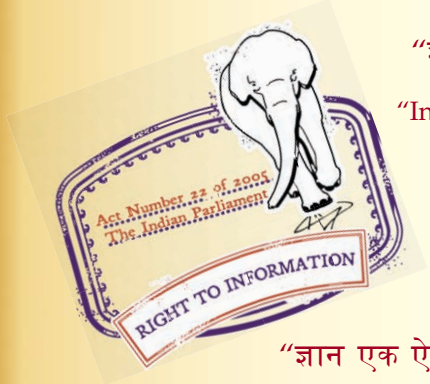

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Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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(Reaffirmed 2006)

Indian Standard

SPECIFICATION FOR ELECTROPLATED COATINGS OF ZINC ON IRON AND STEEL

(Second Revision)

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May 1974

Indian Standard

SPECIFICATION FOR ELECTROPLATED COATINGS OF ZINC ON IRON AND STEEL

(Second Revision)

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SPECIFICATION FOR ELECTROPLATED COATINGS OF ZINC ON IRON AND STEEL

(Second Revision)

0. FOREWORD

0.1 This Indian Standard (Second Revision) was adopted by the Indian Standards Institution on 10 September 1986, after the draft finalized by the Metallic and Non-metallic Finishes Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard was first published in 1960, revised in 1970 and covered three types of zinc plating depending on the coating thickness. In the first revision of the standard, grades of thickness were revised keeping in view the utility of the coatings and the trade practices followed in the country. In this revision, efforts have been made to include many details to make this standard a comprehensive one. Additional terms are included under terminology, limitations are referred to regarding finish and appearance under coating requirements. More details are furnished under information to be given by the purchaser and the manufacturer regarding chromate passivation, test for coatings, handling, inspection, packaging and service life of the coatings.

0.3 Unlike cadmium, zinc is of low toxicity and zinc coatings are widely used but prolonged contact with some liquids or damp foodstuffs which are acidic or liable to become acidic, should be avoided.

0.4 Zinc protects steels cathodically, that is by sacrificial protection in most environments and this protection is given to steel even at discontinuities in the coatings. But zinc plating looses its initial bright appearance due to environmental conditions like dust, condensed moisture at high relative humidities, acidity, high ambient temperatures, etc, and forms bulky, white corrosion products, usually of basic zinc carbonate. One of the best methods of retarding this type of corrosion is by the application of inhibitive chromate passivation films. Passivation by chromate conversion coatings gives additional protection against corrosion and should be

applied unless there is a reason to the contrary. Articles which are to be frequently painted may require alternative treatment such as phosphating to provide good adhesion. Chromated zinc coatings may also be further protected, if necessary, by water-based lacquer, or nitrocellulose (NC) lacquer (conforming to IS : 349-1981*) or any transparent lacquer coatings. NC lacquer coatings give better corrosion protection under tropical conditions than water-soluble lacquer.

NOTE — Chromate passivated zinc coatings contain hexavalent chromium which may irritate the skin and cause ulcers on the skin. Cotton, nylon or rubber hand gloves may be used to prevent skin ulceration while handling chromated zinc coated parts. This will also prevent finger print corrosion on zinc coatings.

0.5 This standard includes the whole range of iron and steel products as basis metals. Designers are advised, however, that all forms of iron and steel are not equally readily electroplated. Many castings can be satisfactorily plated but are apt to be more difficult than forgings. Acid zinc plating baths or neutral chloride baths are available commercially to plate satisfactorily the carbo-nitrided steel castings and other difficult-to-plate iron and steel substrates. Conventional cyanide and low cyanide baths may also be used with adequate precleaning steps.

0.5.1 Attention is also drawn to the effects of the contour of the article to be plated. In general, the requirements for minimum thickness apply only to those portions of the article which can be described as significant surfaces. It helps to reduce process costs if the designer of an electroplated part consults a plating specialist before the design is finally issued for production.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers requirements for electrodeposited zinc coatings applied to iron or steel articles except for coatings applied to components having threads of basic major diameter from 1·25 to 12·5 mm and coatings applied to sheet or wire in the unfabricated form or to close-coiled springs.

*Lacquer, cellulose nitrate, clear, finishing, glossy for metal (*first revision*).

†Rules for rounding off numerical values (*revised*).

1.2 Requirements are specified for appearance, thickness, adhesion, heat treatment before or after plating, precleaning standards, and if the coating is chromate-passivated, the corrosion resistance.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Surface — The part of the surfaces on which the electroplater has to work.

2.2 Significant Surface — Significant surfaces are those surfaces, normally visible, which are essential to the appearance or serviceability of the article when assembled in normal position, or which may be the source of corrosion products that deface visible surfaces on the assembled article and are subject to wear or corrosion or both, or surfaces on which the coating is otherwise functionally necessary. This applies also to surfaces visible by reflection

NOTE 1 — The significant surface may be generally defined as that part of the visible surface which can be touched with a ball of diameter 20 mm or a diameter agreed upon by the manufacturer and the purchaser.

NOTE 2 — The designation of significant surface shall be agreed upon by the manufacturer and the purchaser and may be indicated in the drawings.

2.3 Non-significant Surfaces — Surfaces such as holes, recesses, bases of angles and similar areas where a controlled deposit ordinarily cannot be obtained, are designated as non-significant surfaces.

2.4 Minimum Local Thickness — This is defined as the lowest value of the coating thickness at any point on the significant surfaces.

2.5 Minimum Average Thickness — This is the average of thicknesses at a number of points on the significant surfaces.

2.6 Iridescent Passivation — When a stable and adherent chromate coating is formed over zinc electrodeposits by reaction with an acidified dichromate solution under suitable *p*H and duration of passivation, producing more than one or two intermingling colours, the passivation is termed as iridescent passivation.

2.7 Post-Plating Treatment — Heat treatment for relief of hydrogen embrittlement, bright dipping, chromate passivation, dyeing, lacquering, painting or other organic coatings after plating are termed post-plating treatments.

2.8 Hydrogen Embrittlement — Embrittlement caused by the entry of hydrogen into a metal.

3. COATING CLASSIFICATION NUMBER

3.1 Manner of Specifying Requirements — When ordering the electroplating of articles, the purchaser shall state the number of this standard, the date of issue, the class or service condition number and type (*see* **3.2** and **3.3**).

3.1.1 If necessary, the purchaser shall include, on his part, drawings or purchase order giving the following:

a) Electroplating application to high-strength steel, if specified;

b) Thickness, if other than that specified in this standard;

c) Lustre;

d) Location of significant surface;

e) Corrosion resistance test, if specified;

f) Hydrogen embrittlement test, if required;

g) Sample size for inspection, if other than the specified; and

h) Supplementary treatment, if applicable as per Table 1.

3.2 Grading of Service Conditions — In order of increasing severity of service conditions, numbers 1 to 4 have been allotted to be referred to as Service Grade Numbers. The purchaser shall specify the service grade number and, if desired, also the classification number (*see* **3.3.1**). Typical service conditions which correspond to various service grade numbers have been explained in Appendix A for guidance.

3.2.1 Service life of zinc coatings has been given in Appendix B for guidance only.

3.3 Classification of Coating

3.3.1 The classification number comprises:

a) chemical symbol for the basis metal (iron or steel), Fe;

b) chemical symbol for zinc, Zn; and

c) a number indicating the minimum local thickness of zinc in micrometres.

TABLE 1 SUPPLEMENTARY TREATMENTS

(*Clauses* 3.1.1, 3.3.2, 4.1.2, 4.5.1 *and* 9.2.3)

Sl No.	Type		Typical Appearance	Approximate Film Density	Typical Chromium Content
	(1)		(2)	(3) g/m²	(4) mg/m²
1.	*Chromate Conversion Coatings*:				
	A Clear	Colourless	Transparent clear, sometimes with a bluish tinge	Up to 0·5	5
	B Bleached	Colourless	Transparent with slight iridescence	Up to 1·0	5 to 10
	C Iridescent	Coloured	Yellow iridescent	0·5 to 1·5	50 to 100
	D Opaque	Coloured	Olive green, shading to brown or bronze	More than 1·5	100 to 200
2.	*Phosphate Coatings*:				
	E		Phosphate conversion coating (*see* Note 2)		

NOTE 1 — The supplementary treatment types A, B, C and D shall be further protected by organic protective coatings like water soluble lacquer, nitrocellulose lacquer or paint, if specified by the purchase order.

NOTE 2 — Type E shall be covered by painting, if specified in the purchase order. The type of phosphate coating shall be specified as light, medium or heavy (according to IS : 3618-1966 'Specification for phosphate treatment of iron and steel for protection against corrosion').

3.3.2 The type number indicating the nature of conversion coatings applied is given in Table 1.

4. COATING REQUIREMENTS

4.1 Finish and Appearance

4.1.1 Over the significant surface, the plated article shall be free from clearly visible plating defects such as blisters, pits, roughness, nodules, cracks, burning or unplated areas and shall not be stained or discoloured. On articles, usually where a contact mark is inevitable, this contact mark is excluded for inspection of appearance. Superficial stains that result from

rinsing or slight discolouration resulting from drying or heating operation to relieve hydrogen embrittlement shall not be the cause for rejection.

NOTE 1 — Unless otherwise specified, the finish shall be bright, semi-bright or dull. The plated article shall, however, be clean and free from any damage.

NOTE 2 — Defects on the surface of the basic metal, such as scratches, porosity, pits, inclusions, cracks, roll marks and die marks may adversely affect the appearance of coatings applied thereto, despite the observance of the best electroplating practices. Accordingly, the electroplater's responsibility for defects in the coating resulting from such conditions shall be waived.

4.1.2 *Supplementary Treatments* — Appearance of supplementary treatments shall be as given in Table 1.

4.2 Thickness and Type of Zinc Coating

4.2.1 *Thickness* — The minimum thickness of zinc coating is designated by the classification number (*see* **3.3**).

4.2.1.1 *Local thickness* — The minimum local thickness of the zinc coating shall be measured at points on the significant surface as agreed to between the purchaser and the supplier and shall satisfy the requirements of Table 2.

TABLE 2 REQUIREMENTS OF ZINC COATINGS ON IRON AND STEEL

(*Clauses* 4.2.1.1 *and* 4.2.1.2)

SERVICE GRADE NO.	CLASSIFICATION NO.	LOCAL THICKNESS, *Min*	AVERAGE THICKNESS, *Min*
(1)	(2)	(3)	(4)
		μm	μm
4	Fe/Zn 25	25	38
3	Fe/Zn 12·5	12·5	18
2	Fe/Zn 7·5	7·5	12
1	Fe/Zn 5	5	8

NOTE 1 — In any particular environment, the protective value of a zinc coating is directly proportional to its mass per unit area. Therefore, a coating of 40 μm minimum thickness and 60 μm average thickness may also be used for special purposes. When very long service life is required, for example, on structural steel components, the thicker zinc coatings required are usually applied by hot-dip galvanizing or by zinc spraying.

NOTE 2 — Barrel-plated items like screws, nuts, bolts, etc, are usually plated according to classification Fe/Zn 5 and Fe/Zn 7·5. Tolerances and inspection procedure shall be as agreed mutually.

NOTE 3 — Average thickness is determined for small parts and fasteners where minimum local thickness cannot be determined.

4.2.1.2 *Average thickness* — In cases, where it is not possible to measure local thickness, the average thickness of zinc coating shall satisfy the appropriate requirements of Table 2.

4.3 The zinc coating shall not contain mercury, unless otherwise desired by the purchaser.

4.4 Lustre — Unless otherwise specified by the purchaser, a bright, semi-bright or dull lustre shall be acceptable.

4.5 Corrosion Resistance

4.5.1 *Coloured Coatings* — Coloured coatings (Types C and D as given in Table 1) on zinc coatings shall be subjected to neutral salt spray test as specified in IS : 9844-1981*. White corrosion products shall not be visible within 96 hours.

4.5.2 *Colourless Coatings* — Colourless coatings (Types A and D as given in Table 1) on zinc coatings shall be subjected to neutral salt spray test without break-down of the coating or any appearance of white corrosion products within 12 and 24 hours respectively, when carried out by the procedure given in IS : 9844-1981*.

NOTE 1 — Black spots shall be ignored for corrosion interpretations and shall not be the criteria for rejection.

NOTE 2 — The failure of the test is defined as the first appearance of the white corrosion products on surfaces visible to the unaided eye at normal reading distance. However, appearance of black spots and white corrosion products on very low current density areas, sheared edges, formed edges, very near pierced/tapped/blind holes, plots, contact/wiring points, bases of angles, curves and threaded portions shall be ignored.

NOTE 3 — Bimetal contact points/inside of blind holes shall be protected suitably against galvanic corrosions.

5. BASIS METAL

5.1 Cleaning of Basis Metal — Proper preparatory procedures and thorough cleaning of the basis metal are essential to ensure satisfactory adhesion and corrosion resistance performance of the coating. The cleaning shall be done in accordance with the method prescribed in IS : 3194-1980†.

5.2 Unless otherwise specified, high-strength steels having a tensile strength greater than 1 500 MPa (corresponding hardness 45 HRC, 440 HV or

*Methods of testing corrosion resistance of electroplated and anodized aluminium coatings by neutral salt spray test.

†Recommended practice for cleaning metals prior to electroplating (*first revision*).

415 HB approx) should not be electroplated with zinc by conventional methods.

6. HEAT TREATMENT

6.1 Heat treatment shall be performed on certain basis metals to reduce the risk of damage by hydrogen embrittlement. In all cases, the duration of heat treatment shall commence from the time at which the whole of each part attains the specified temperature.

6.1.1 Parts made from steels with maximum specified tensile strengths of 1 050 MPa or higher (corresponding hardness values of approximately 34 HRC, 340 HV or 325 HB) and surface-hardened parts shall require heat treatment. It is recommended that unless otherwise specified, steels having tensile strength greater than 1 450 MPa (corresponding hardness 45 HRC, 440 HV or 415 HB) should not be electroplated with zinc by conventional methods.

6.2 With the exception of surface-hardened parts, the heat treatment conditions shall be selected on the basis of the specified maximum tensile strength. Steels shall be categorized according to specified maximum tensile strength according to Table 3. If the steel specification is only in terms of minimum tensile strength, the corresponding maximum tensile strength shall be determined from Table 3.

TABLE 3 CATEGORIES OF STEELS AND MAXIMUM TENSILE STRENGTH CORRESPONDING TO SPECIFIED MINIMUM TENSILE STRENGTH

Sl No.	Minimum Specified Tensile Strength, *Rm* *Min*	Corresponding Maximum Tensile Strength, *Rm* *Max*
(1)	(2)	(3)
	MPa	MPa
i)	$Rm\ Min \leq 1\,000$	$Rm\ Max \leq 1\,050$
ii)	$1\,000 < Rm\ Min \leq 1\,400$	$1\,050 < Rm\ Max \leq 1\,450$
iii)	$1\,400 < Rm\ Min \leq 1\,750$	$1\,450 < Rm\ Max < 1\,800$
iv)	$1\,750 < Rm\ Min$	$1\,800 < Rm\ Max$

6.3 Stress-Relief Before Plating — All steel parts having an ultimate tensile strength of 1 050 MPa (corresponding hardness 34 HRC, 340 HV or 325 HB approx) and above, and that have been machined, ground or cold-formed, or cold-strengthened, shall be heat-treated for stress-relief. As a

guide, they may be heat-treated at the highest temperature within the limit imposed by the tempering temperature for 30 minutes or maintained at a temperature of 190 to 220°C for not less than 1 hour.

NOTE 1 — If stress-relief is given after shot-peening or other cold working processes, the temperature shall not exceed 220°C.

NOTE 2 — Some steels which have been carburized, flame hardened or induction hardened, and subsequently ground would be impaired by the treatment given in Note 1 and should instead be stress-relieved at a lower temperature, for example, at 170°C for not less than 1 hour. Guidance is given in Table 4.

TABLE 4 GUIDANCE OF HEAT TREATMENT FOR STRESS-RELIEF BEFORE ELECTROPLATING

(EXCLUDING SURFACE-HARDENED PARTS)

SL NO.	MAXIMUM SPECIFIED TENSILE STRENGTH, *Rm Max*	TEMPERATURE	TIME
(1)	(2)	(3)	(4)
	MPa	°C	h
i)	*Rm Max* $\leq$ 1 050	Not required	—
ii)	1 050 $<$ *Rm Max* $\leq$ 1 450	190-220	1
iii)	1 450 $<$ *Rm Max* $\leq$ 1 800	190-220	18
iv)	1 800 $<$ *Rm Max*	190-220	24

6.4 Heat-Treatment After Plating Hydrogen Embrittlement Relief — Components subject to fatigue or sustained loading stress in service and made from severely cold-worked steels or nitrided steels or steels of tensile strength of 1 050 MPa (corresponding hardness 34 HRC, 340 HV, 325 HB approx) or greater should be heat-treated after plating. Guidance is given in Table 5.

6.4.1 In case the heat-treatment temperature would be harmful, for example, to surface-hardened steels (except for nitrided steels), it may be necessary to apply a lower temperature for a longer time.

NOTE 1 — The baking should be done as soon as possible after electroplating and before any supplementary chemical treatment of the plated surfaces. The best time and temperature in some cases shall be established by experiment.

NOTE 2 — Electroplated springs and other parts subject to flexure shall not be flexed before the hydrogen embrittlement relief treatment. Steel springs shall be treated in boiling water for not less than 2 hours. The spring rating may be affected at a higher temperature.

NOTE 3 — Other conditions of time and temperature may be specified and used if they have been shown to be effective for the particular part and are acceptable to the purchaser but parts shall not be heat-treated above their tempering temperature.

TABLE 5 GUIDANCE OF HEAT TREATMENT FOR HYDROGEN EMBRITTLEMENT RELIEF AFTER ELECTROPLATING (EXCLUDING SURFACE-HARDENED PARTS)

SL NO.	MAXIMUM SPECIFIED TENSILE STRENGTH, *Rm Max*	TEMPERATURE	TIME
(1)	(2)	(3)	(4)
	MPa	°C	h
	Rm Max ≤ 1 050	Not required	—
	1 050 < *Rm Max* ≤ 1 450	190-220	8
	1 450 < *Rm Max* ≤ 1 800	190-220	18
	1 800 < *Rm Max*	190-270	24

6.5 Activation Treatment — Electroplated surfaces passivated as a result of the baking operation shall be reactivated before receiving a supplementary treatment. Surface intened for supplementary treatment, namely, A, B, C and D types may be activated by immersion in a dilute acid solution. Surfaces shall be activated as soon as possible following baking and should be handled carefully to avoid contamination.

7. SELECTION OF SAMPLES

7.1 Out of each lot of similar parts, a number of samples shall he selected at random. The size of the lot and the number of samples to be selected shall be agreed upon between the manufacturer and the purchaser. All the samples selected shall be visually examined for any defects referred to in.

8. TEST SPECIMENS

8.1 If separate test specimens are used to represent the coated articles in a test, the specimens shall be of the same nature, size and number and be processed as required in the purchaser's order.

8.1.1 Unless a need can be demonstrated, separately prepared specimens shall not be used in place of production items for non-destructive and visual examinations.

8.2 Thickness and Adhesion Test Specimens — If separate specimens for thickness and adhesion tests are required, the strips shall be used approximately 25 mm in width, 100 mm in length and 1 mm in thickness.

8.3 Corrosion Resistance Test Specimens — If separate specimens for corrosion resistance tests are required, the panels not less than 150 mm in length, 100 mm in width and approximately 1 mm in thickness shall be used.

8.4 Hydrogen Embrittlement Test Specimens — If specimens are required, the configuration shall be specified by the purchaser.

9. TEST METHODS

9.1 Supplementary Treatments

9.1.1 The supplementary film treatments (*see* Table 1) for Types A, B, C and D shall be in accordance with IS : 9839-1981*. The treatment required for conversion to Type E (phosphate coating) shall be in accordance with IS : 3618-1966†.

NOTE — The zinc surface is attacked by supplementary treatments, thereby diminishing the amount of metallic zinc present. Therefore, it is recommended that no supplementary treatments be applied to zinc coatings, having a minimum thickness of 3 micrometres.

9.1.1.1 *Appearance of chromate coating* — The appearance of a chromate film on zinc coating may vary from as olive drab, olive green shading to brown or bronze, iridescent to colourless. In case of iridescent passivation, the combination of colours will vary according to the process conditions like *p*H, conditions of the basis metal and zinc deposit, temperature, time of reaction, agitation and composition of the passivation bath.

9.1.1.2 *Performance of chromate coating* — The passivated article shall be subjected to the humidity test described in Appendix C. Breakdown of the film or the appearance of white corrosion products after 2 cycles of the test constitutes failure to comply with this standard.

9.1.1.3 *Covering* — A chromate film shall be free from bare patches. The presence of the film is verified by the test method prescribed in Appendix D for colourless and bleached passivation.

9.1.1.4 *Adhesion* — A chromate film shall be adherent, when tested by one of the methods described in IS : 8602-1977‡.

*Specification for chromate conversion coatings or electroplated zinc and cadmium coatings.

†Specification for phosphate treatment of iron and steel for protection against corrosion.

‡Methods of tests for chromate conversion coatings on zinc and cadmium surfaces.

9.2 Thickness

9.2.1 *Local Thickness* — The local thickness of the coating may be determined by methods as given in IS : 3203-1982*.

9.2.2 The method given in Appendix E shall be used for determining average thickness in case of zinc plated fastener hardware.

NOTE 1 — Other methods may also be used if it can be demonstrated that the uncertainty of the measurement with these methods is less than 10 percent.

NOTE 2 — If the coatings are rough or matt, the microscopical and profilometric methods may give unreliable results, and magnetic/eddy current methods may give measurements which are somewhat greater than those obtained on smooth coatings of the same mass.

9.2.3 Thickness measurements of zinc coatings may be made (for Types A, B, C, D and E) after application of the supplementary treatments. When BNF jet test method as given in IS : 3203-1982* is used, the supplementary treatment prior to testing shall be removed. The chromate film may be removed from Types A, B, C and D as given in Table 1 by using a very mild abrasive (as paste of levigated alumina rubbed on with the finger). Type E coating may be treated with a concentrated (28 percent) ammonia solution to quickly dissolve the phosphate coating without affecting the underlying zinc.

9.3 Adhesion — Adhesion of the coating shall be such that when examined in accordance with Appendix F, the coating shall not show separation from the basis metal at the interface.

9.4 Corrosion Resistance — When specified in the contract or purchase order, corrosion resistance shall be determined in accordance with IS : 9844-1981†. The samples shall be subjected to salt spray test; the length of time to be applicable for the type of supplementary coating shall be in accordance with the requirements given in IS : 9839-1981‡. To secure uniformity of results, Types A, B, C and D supplementary coatings shall be aged at room temperature for 24 hours before subjecting to salt spray test.

9.5 Visual Examination — Each article shall be examined for compliance with requirements of lustre (**4.4**) and appearance (**4.1** and **9.1.1.1**) after electroplating and passivation.

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*Methods of testing local thickness of electroplated coatings (*first revision*).

†Methods of testing corrosion resistance of electroplated and anodized aluminium coatings by neutral salt spray test.

‡Specification for chromate conversion coatings on electroplated zinc and cadmium coatings.

10. REJECTION

10.1 Coatings not conforming to this specification or to authorized modifications shall be rejected.

11. TEST REPORT

11.1 If mutually agreed, the manufacturer/supplier shall furnish the test report and test certificate stating that the finished product conforms to this standard.

12. PACKAGING AND PACKING

12.1 Presentation, packaging, and packing methods for zinc electroplated parts or articles employed by a supplier shall be such as to preclude any damage during shipment and handling.

13. MARKING

13.1 The marking related to the coating shall include service grade and classification numbers as specified in this standard and the name or trade mark of the manufacturer.

13.1.1 The coated article may also be marked with the Standard Mark which shall relate to the coating of the article.

13.1.2 The use of the Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

APPENDIX A

(*Clause* 3.2)

EXAMPLES OF SERVICE CONDITIONS

A-1. SERVICE GRADE NUMBER 4

A-1.1 Severe involving either continuous or intermittent outdoor exposures and prone to scratching and abrasive wear examples of articles subjected to such conditions are tubular furniture, screws, window fittings, builders' hardware, military hardware, washing machine parts, bicycle parts, etc.

A-2. SERVICE GRADE NUMBER 3

A-2.1 Severe involving indoor exposures and prone to scratching and abrasive wear to some extent. Example of articles subjected to such conditions are tools, zippers, machine parts, etc.

A-3. SERVICE GRADE NUMBER 2

A-3.1 Involving indoor exposures normally with occasional condensation, and subjected to minimum wear or abrasion. Examples of articles subjected to such conditions are barrel-plated items like fasteners, washers, nuts, screws, bolts, etc.

A-4. SERVICE GRADE NUMBER 1

A-4.1 Mild involving indoor exposures without condensation and subjected to minimum wear or abrasion.

APPENDIX B

(*Clause* 3.2.1)

RECOMMENDED SERVICE LIFE OF ZINC

B-1. SERVICE LIFE OF ZINC

B-1.1 The service life of zinc coating is a function of thickness and the type of environment to which it is exposed. Though it is not possible to predict the exact life, guidelines (very approximate) are available on the basis of world-wide collection of corrosion data.

Atmosphere	*Mean Corrosion Rate*
Industrial	5·6 μm/year
Urban, non-industrial or marine	1·5 μm/year
Suburban	1·3 μm/year
Rural	0·8 μm/year
Indoors	Considerably less than 0·5 μm/year

NOTE 1 — The mean corrosion rates given above are subjected to wide variations and are relative values only.

NOTE 2 — The mean corrosion rates are applicable to zinc only and do not include corrosion rates when zinc is passivated or is in contact with other materials.

APPENDIX C

(*Clause* 9.1.1.2)

HUMIDITY TEST

C-1. APPARATUS

A heat-insulated chamber. A fan to circulate air in the chamber and non-corrosive support for the specimen near the centre of the chamber constitute the humidity chamber.

C-2. TEMPERATURE OF THE TEST

The test shall be conducted at a temperature of 55 ± 2°C followed by cooling to 30°C.

C-3. HUMIDITY

The relative humidity shall not be less than 95 percent.

C-4. TEST CYCLE

The article shall be subjected to the above mentioned temperature and humidity conditions for 16 hours continuously. The source of heat shall then be turned off. Circulation of the air shall be maintained. The temperature shall be allowed to fall to 30°C. The article shall be kept at this temperature for 5 hours. The article shall be examined after each cycle.

APPENDIX D

(*Clause* 9.1.1.3)

TEST FOR CHROMATE FILM

D-1. TEST SOLUTION

D-1.1 The test solution shall have the following composition:

a) Distilled water	40 ml
b) Glacial acetic acid	60 ml
c) Diphenyl carbozide	1 g
d) Wetting agent (sulphonated alcohol type)	0·1 g
e) Concentrated hydrochloric acid (relative density 1·16)	15 ml
f) Sodium hypochlorite (10-15 percent solution)	30 ml
g) Hydrogen peroxide (100 vol)	5 ml

NOTE — The reagents shall be added in the above order and the resulting solution left in an open beaker for about 24 hours in order to allow excess chlorine to escape before use.

D-2. PROCEDURE

A drop of the test solution shall be applied to the coated sample. The formation of a red or purple colouration within five minutes of applying the drop denotes the presence of the chromate film. In case of bleached or colourless coatings, the colour will be less intense.

APPENDIX E

(*Clause* 9.2.2)

METHOD FOR DETERMINATION OF AVERAGE THICKNESS

E-1. STRIPPING SOLUTION

Dissolve 20 g of antimony trioxide in 1 000 ml of cold, concentrated hydrochloric acid (relative density 1·16).

E-2. PROCEDURE

Accurately determine the area of the plated part. Degrease it with an organic solvent such as trichloroethylene, dry thoroughly and weigh to an accuracy of one part in 10 000. Then totally immerse it and turn it over so that the reagent has free access to all surfaces. After the effervescence has ceased, remove the loose coating of antimony and immerse in clean acetone to remove any trapped water. Then remove the sample, dry by the process previously used and reweigh.

NOTE 1 — If the article is of complex shape, an area should be agreed to between the contracting parties.

NOTE 2 — The presence of a chromate passivation film can be ignored in this test.

E-3. CALCULATION

$$\text{Zinc coating thickness in micrometre} = \frac{141 \times 10^3 (m_1 - m_2)}{A}$$

where

m_1 = original mass in g of the sample,

m_2 = final mass in g of the sample, and

A = area in mm² of coating.

NOTE — The above calculation assumes a density of 7·1 g/cm³ for zinc.

APPENDIX F

(*Clause* 9.3)

BURNISHING TEST FOR ADHESION

F-1. Rub an area of not more than 650 mm² of the plated surface, selected at the discretion of the inspector, rapidly and firmly with a smooth metal implement for 15 seconds.

F-2. A suitable burnishing implement is a copper disc (for example, a copper coin) used edgewise and broadside. The pressure shall be sufficient to burnish the film at every stroke but not so great at to cut the deposit. A poor adhesion will be shown by the appearance of a loose blister which grows as the rubbing is continued. If the quality of the deposit is also poor, the blister may crack and the plating will peel away from the base metal.

F-3. More than one area may be tested, if desired.

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